# 144: Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms

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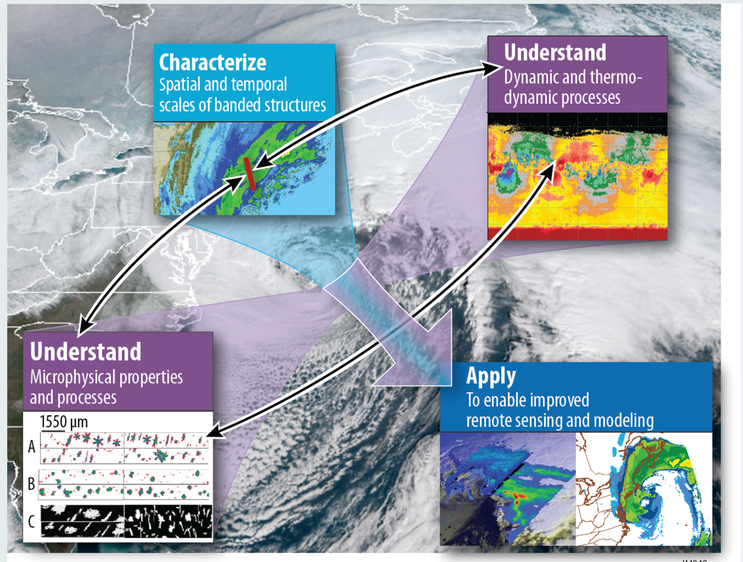
## Overview

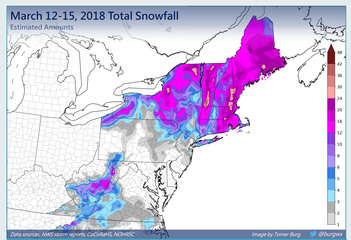
A newly selected Earth Venture Suborbital (EVS-3) investigation will explore how multi-scale dynamical and microphysical processes in winter storms interact to produce banded regions of snow in Atlantic coast-threatening snowstorms




### Motivation

- Snowstorms are frequent along the US East Coast and cause major disruptions to transportation, commerce and public safety
- Snowband structures result from multi-scale dynamical, thermodynamical and microphysical processes and are poorly understood
- Snowfall distribution and amount is often poorly predicted
- Remote sensing of snowfall is difficult and additional observations are needed to improve algorithms
- No major field study of East Coast US snowstorms has occurred over the last 30 years.

Modest amounts of snowfall can cause devastating problems on the nation's roadways. IMPACTS observations will help improve forecasting, reducing impacts on commerce and public safety



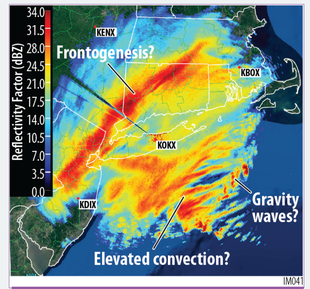

Snowfall totals can vary greatly due to banded structures within the storm systems. The complex multi-scale dynamical and microphysical processes will be studied during IMPACTS. This will provide knowledge that will inform remote sensing of snow from space and improve US storm prediction capabilities.

### Observations made during IMPACTS applies to remote sensing

- **GPM** and the **Decadal Survey Couds, Convection and Precipitation Targeted Observable** will both benefit from the observations taken during IMPACTS to improved remote sensing of snow in winter cyclones

## The Science

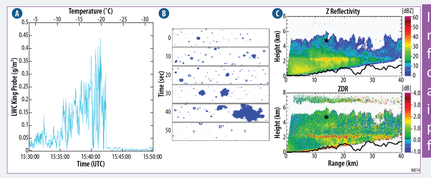
1. **CHARACTERIZE** the spatial and temporal scales and structures of snowbands in Northeast US winter storms
2. **UNDERSTAND** the dynamical, thermo-dynamical, and microphysical processes that produce the observed structures
3. **APPLY** this understanding of the structures and underlying processes to improve remote sensing and modeling of snowfall




Snowbands occur on multiple scales. IMPACTS will investigate the mechanisms that drive their initiation and growth

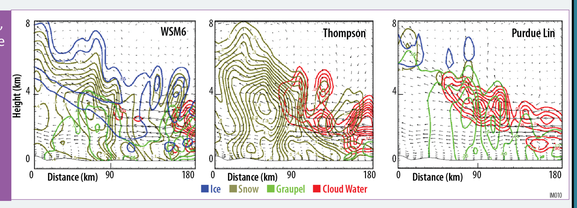
### Characterize and understand snowband formation

- What are the vertical and horizontal structures and scales of the bands and how do these structures evolve with the development of the cyclone?
- How do patterns of vertical motion (i.e. updrafts) relate to snowband structure and what dynamical and thermodynamical processes (e.g. frontogenesis, shear instability, conditional or symmetric instability, gravity waves) determine the initiation, size, evolution, and longevity of these vertical motions?
- To what extent are areas of enhanced reflectivity in bands related to increased snow water content versus changes in particle characteristics due to aggregation or riming without a significant change in snow water content?



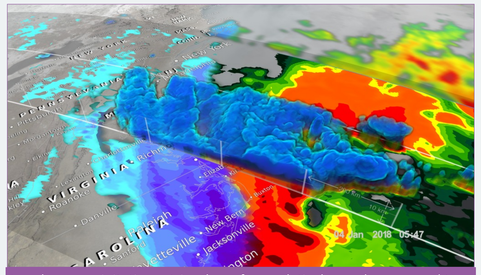

IMPACTS will provide important aircraft *in-situ* microphysical observations such as these examples from the OLYMPEX field campaign. Microphysical quantities, such as total supercooled liquid water (A), and particle phases, sizes and shapes (B), can aide interpretation of remote sensing observations (C) and provide critical insight into the mechanisms responsible for precipitation growth and organization.

WRF microphysics schemes (i.e. WSM6, Thompson and Purdue Lin) exhibit large differences in mixing ratios for all hydrometeor types. *In-situ* microphysical and remote sensing measurements by IMPACTS will determine which schemes best simulate the vertical structure of quantities such as cloud water, ice and snow mixing ratios.

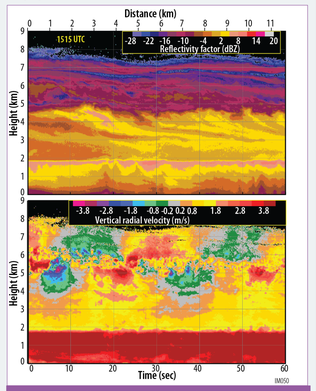



### Apply IMPACTS observations to remote sensing and modeling

- IMPACTS measurements will address the challenges of remote sensing of snowfall and ice processes (such as complex particle geometry and weak path-integrated attenuation) by coupling multi-wavelength radar measurements with *in-situ* microphysical data (e.g. size and aspect ratio spectra) and intrinsic data (e.g. cloud liquid water).
- IMPACTS observations will aid in assessment of the skill of different microphysical schemes and help address reasons why models poorly predict the distribution, intensity and amount of snowfall in storms.
- Data assimilation of IMPACTS observations into the WRF model will be used to create 4-D analyses of storms to investigate the structure and evolution of multiscale bands.

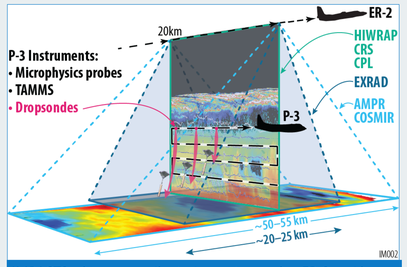



Ice-phase precipitation retrievals perform relatively poorly compared to rain retrievals from spaceborne sensors. The measurements from IMPACTS will improve and constrain retrieval algorithms.

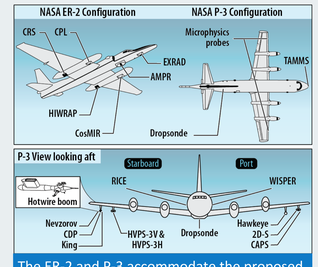



IMPACTS will capture rarely observed finescale vertical structure in winter storms, like this example of a vertical cross section of W-band reflectivity (top panel) and Doppler velocity (bottom panel) in a winter storm.

## Observation Strategy



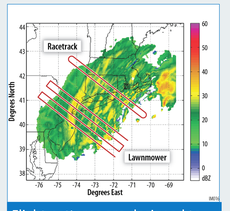

IMPACTS will use coordinated remote-sensing ER-2 and in-situ sampling P-3 flights to study the structure, dynamics, and microphysical characteristics of banded structures in winter storms.



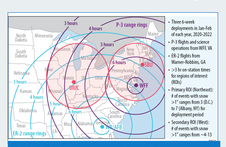

The ER-2 and P-3 accommodate the proposed IMPACTS instruments. All of the ER-2 instruments and many of the P-3 instruments have flown in previous missions.

### IMPACTS Observations will include

- Active and passive microwave remote sensing on the ER-2 and in-situ microphysics on the P-3 aircraft
- Dropsonde profiles over the ocean from P-3, supplemental soundings from NOAA and mobile sounding units
- New York State Mesonet ground observations
- Ground-based radar resources at SUNY Stonybrook



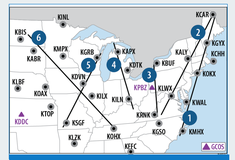

Flight patterns are designed to frequently sample across snowband structures.



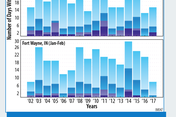

IMPACTS' two main ROIs

| IMPACTS' Instrumentation | | |
|---|---|---|
| **ER-2 Aircraft: Remote Sensing Instruments** | | **Org** |
| CRS | Cloud Radar System | GSFC |
| HIWRAP | High-altitude Imaging Wind & Rain Airborne Profiler | GSFC |
| EXRAD | ER-2 X-Band Doppler Radar | GSFC |
| CoSMIR | Conical Scanning Millimeter-wave Imaging Radiometer | GSFC |
| AMPR | Advanced Microwave Precipitation Radiometer | MSFC |
| CPL | Cloud Physics Lidar | GSFC |
| **P-3 Aircraft: *in-situ* Instruments** | | **Org** |
| CDP | Cloud-Droplet Probe | UND |
| CAPS | Cloud, Aerosol and Precipitation Spectrometer | UND |
| 2D-S | 2D-S Probe | UND |
| HVPS-3 | High Volume Precipitation Sampler-3 | UND |
| Nevzorov | Nevzorov Probe | UND |
| King | King Probe | UND |
| Hawkeye | Hawkeye Probe | GSFC |
| RICE | Rosemount Icing Probe | UND |
| WISPER | Water Isotope System for Precipitation and Entrainment Research | OSU |
| TAMMS | Turbulent Air Motion Measurement System | LaRC |
| AVAPS | Advanced Vertical Atmospheric Profiling System | NCAR |

Instruments deployed on each aircraft



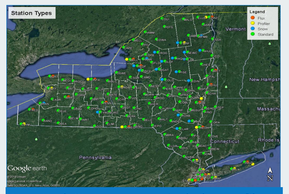

NOAA sounding locations




Snow event climatology

### IMPACTS Deployment

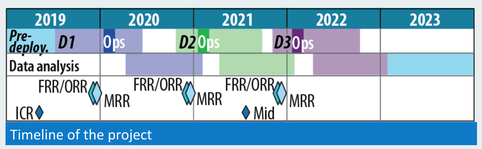
- ER-2 will be based at Warner-Robbins, GA and P-3 at Wallops, VA.
- Operations will be for 6 weeks within the Jan-Mar timeframe starting in 2020 for three consecutive seasons (based on climatology)
- If there are no snowstorms along the Atlantic Seaboard, operations may move to the midwest near University of Illinois



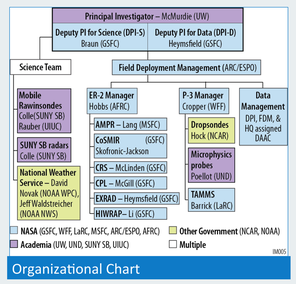

New York State mesonet includes profilers, lidars, flux measurements and flux towers

### SUNY Stonybrook Instrumentation

- Ka scanning polarimetric cloud radar
- Micro Rain Radar and Doppler lidar
- Low-power phased array radar
- 95-GHz solid state radar and a Phased-array radar
- Phased-array X-band weather radar




Timeline of the project




Organizational Chart